

Photo by Claudia Schröder-Adams

EARTH SCIENCES DEPARTMENTAL UPDATE NOVEMBER 2018

Celebrating 65 Years of Exploration, Innovation and Discovery

This year we mark the 65th anniversary of Carleton University's Department of Earth Sciences. Students are choosing our programs because of their diversity and high quality, wealth of field opportunities, outstanding opportunities for

original student research, and our reputation as a friendly, active department with a strong community spirit. Our enrolment is strong with 111 undergraduate and 45 graduate students, 31 minors and ~2100 students per year registered in

general interest courses such as Climate Change, Dinosaurs and Natural Disasters. We are proud of our new teaching and research laboratories, the result of a multi-year expansion and renovation of department space.

A SPECIAL THANKS TO OUR DONORS

Our partnerships provide students with a great education and real-world experience. Our endowments, the Collins, Cox and Jeletzky funds, steadfastly support student participation in field schools, summer internships for students, and

a gemology course. Our students are getting a great education and real-world experience because of tools from major donors: geoLOG-IC systems donation of the geo-SCOUT program for fourth-year students in petroleum geology,

and Schlumberger Ltd. donation of their petroleum systems modelling software, PetroMod. We thank our donors who are supporting funds for the department and for setting up our new endowment, the Charlie Roots Honors Project Fund in Earth Sciences, and to those who are topping up existing scholarships and bursaries.

Alumni Field Trip to Iceland, 2018

Led by Professor Brian Cousens and organized by the Carleton Alumni Association and Worldwide Quest travel, eleven Carleton alumni and friends spent ten days discovering the geology and culture of Iceland. The group examined volcanic features in the Sneafellsnes Peninsula, The Lake Myvatn area, and southern Iceland from Reykjavik to Kirkjubæjarklaustur.



Participants of the 2018 Alumni Iceland field trip enjoying a gorgeous day at Hekla volcano, south-central Iceland.



Group photo of participants of the 2018 Alumni field trip on a rootless volcanic cone, near Kirkjubæjarklaustur, southern Iceland.

Congratulations to Professor Hanika Rizo

Winner of Carleton University 2018 Research Achievement Award

Hanika's project is "Establishing a New Laboratory for the Study of Earth's Earliest Times." How the Earth formed and how it evolved through time are fundamental questions for Earth Sciences. Opportunities to learn about the early history of the Earth have recently opened up due to the development of analytical techniques that allow high-precision analysis of various radioactive isotopic systems. Hanika is establishing an ultra-clean laboratory for such high-precision isotope measurements in rocks. This new laboratory, together with Carleton's advanced instrumentation, will permit the development of innovative analytical techniques that could shed light into the planetary processes that shaped our planet.

You are cordially invited to the PDAC Alumni Reception

Toronto Monday March 4th, 5 pm – 8 pm
British Columbia Room of the Royal York Hotel

Earth Sciences Faculty representatives and current undergraduate and graduate students from Carleton University and University of Ottawa will be there to welcome you.



Dr. Geoff Pignotta

Laboratory Coordinator

Geoff has returned to Canada, and Ottawa, after 9 years teaching experience at the University of Wisconsin-Eau Claire. There he carried out undergraduate student, field-based research in Montana and British Columbia, taught field schools in New Mexico and Montana, led field

experiences to California, Nevada and Nicaragua and taught introductory geology, structural geology and economic geology. Since his start at Carleton, in the fall of 2016, Geoff has revised the first-year laboratories and is developing new field-based labs in hydrogeology, water resources and energy resources, all using campus resources. Geoff is also a key contributor in teaching and curriculum related committees and in improving the experiential-learning framework in the department.



Michelle Co

New Staff Member

As the new "Full Stack Web/Multimedia/Mobile Developer" for the Faculty of Science, Michelle brings over 8 years of

work experience developing design identities, websites, publications, marketing collateral and visual-effects films. Michelle will be creating interactive, immersive web and design experiences for the Faculty of Science. Stay tuned - the first new websites to roll out will be for the Department of Earth Sciences and the Department of Physics.



Retirement of Peter Jones

Microprobe Specialist

We offer a heartfelt thanks to Peter for 44 years of dedicated service, and wish him all the best. Peter

generously taught generations of Earth Scientists the art of microprobe analysis, generated countless high-quality results for students and researchers, was involved in many scientific publications and contributed greatly to the heart and operations of the department over more than four decades.



Class photos through the years

Department History Project. Please help us portray our Department's 65 years of history and adventures. Do you have photos or tales from your time at Carleton? Send your stories, memories and photographs to Sharon Carr (SharonCarr@cunet.carleton.ca). If you went to Spain in 1972 or 1973, on one of our first international field trips, please contact Clinton Tippet who is compiling information clintontippet88@gmail.com.



Drs. Hanika Rizo, Shuangquan Zhang, Sharon Carr and Brian Cousens with the newly installed Neptune mass spectrometer.

The Neptune MC-ICP mass spectrometer laboratory is up and running.

The Isotope Geochemistry and Geochronology Research Centre (IGGC) is now set up to measure Sr, Nd, Hf and Pb isotopic ratios on the newly installed Neptune instrument. The analysis of other isotopic systems, such as Li, B, K, Mg, Fe, Zn, W and laser ablation zircon Hf isotopes, will be developed in future.

Teacher Education - Geoheritage Day - Summer Camps for Children, and more...

Thanks to Ms. Beth McLarty Halfkenny and her team of student volunteers for hosting class visits in the department, visiting schools, training teachers, mounting displays, participating in community events and organizing public outreach activities such as Geoheritage Day!



Dr. Hillary Maddin (kneeling front centre) presented the annual Science Literacy Week talk at the Joggins Fossil Institute, Nova Scotia.

Professor Hillary Maddin participated in the 10th Anniversary Celebration of the UNESCO World Heritage site at the Joggins Fossil cliffs, Nova Scotia.

Joggins is home to a Carboniferous outcrop of global significance hosting the oldest fossil amniote tetrapods (i.e. limbed animals), the oldest reptiles, and a wealth of insects and other invertebrate creatures. The tetrapod fossils occur within the lithified remains of a 312 million-year-old lycopsid forest. Ongoing research at the locality was highlighted at a Research Symposium in September 2018, and Dr. Hillary Maddin was among the delegates. Hillary runs an annual field program at Joggins where she and her students search for new fossil discoveries as part of a research program aimed at understanding the origin and evolution of early tetrapods.

Summer 2018

Earth Sciences and Sports Camp

One hundred and fifty children, ages 8 to 12, explored Earth Sciences in our labs and outdoor spaces this past summer. Campers experimented with model volcano eruptions, explored earthquake-proof building designs with our “shake tables,” learned how to stabilize slopes to prevent landslides, researched a dinosaur trackway, cut open geodes in our sample preparation laboratory, and took home hand lenses and a collection of rocks, minerals and fossils. In addition to the campers’ learning and experiences, the project provided employment and leadership opportunities for three Earth Sciences students and generated funds for our Outreach Programs.



Model Volcano -Earth Sciences and Sports Camp



Week-Long Teachers Workshop

FIELD-BASED EXPERIENTIAL LEARNING

Discovering Earth Sciences: An
Interactive Summer Field Workshop
for Teachers - Rockport

Eleven educators participated in a field course based in Eastern Ontario, led by Ms. Beth McLarty Halfkenny and Professor Claudia Schröder-Adams. Field trips and evening projects modeled inquiry-based learning and provided an opportunity for teachers to im-

merse themselves in experiential learning. The aims were to provide teaching resources to educators and encourage them to implement inquiry-based teaching methods and build Earth Sciences into their lessons. Our intrepid first class gave thoughtful feed-

back, reporting that they were, "inspired to use the activities and ideas in their classrooms." We look forward to bringing this experience to another cohort of educators in 2020.

10th annual Geoheritage Day – September 29th

Approximately 150 visitors, of all ages, investigated field sites at the Champlain Bridge Stromatolites, Gatineau; Cardinal Creek Karst, Orleans; Mer Bleue Bog, Orleans; Hog's Back Park, Ottawa; Pinhey Sand Dunes, Nepean; and the Carleton University campus. The Earth Sciences Sample Preparation Lab did a steady business at their "rock clinic" identifying and cutting open samples brought in by curious wonderers of all ages. The event was hosted by Beth McLarty Halfkenny, Al Donaldson,

and 15 enthusiastic Graduate and Undergraduate Carleton student volunteers along with several members of the Ottawa-Gatineau Geoheritage Project and our community partners from the Cardinal Creek Community Association and the Biodiversity Conservancy. The volunteers pointed out remarkable natural features at each site, led tours, and explained geologic processes and local geological history. Please join us for our next Geoheritage Day in the Fall of 2019.



Carleton Students Jade Atkins, Zoe Landry and quadruped helper (specializing in public relations)

Newfoundland & Morocco



Students of the EARTH 3203 Applied Sedimentology class examine the Green Point Section in western Newfoundland. These rocks form the Global Stratotype Section and Point (GSSP) for the Cambrian-Ordovician boundary. The boundary lies within the recessive shale interval mid-photo.

Field school on a camel trip in the Merzouga dune field, Morocco.



ERTH 4807

Field Course in Morocco

In late April and early May 8, 2018, Drs. Brian Cousens, Hafida El Bilali, Richard Ernst and 27 students travelled to Morocco. Led by Professor Moha Ikenne, from Université Ibn Zohr in Agadir, the group studied dinosaur tracks, Precambrian sedimentary and metamorphic rocks, Late Proterozoic ignimbrites and stromatolites, Middle Atlas carbonate rocks and tectonic structures, Cretaceous flood basalts and Quaternary lava flows hosting mantle xenoliths. In addition, the group enjoyed Moroccan tea and excellent cuisine and learned about Moroccan culture and politics.

Bay of Islands ophiolite



Depositional Systems

New Delivery of ERTH 3206

This course has moved out of the classroom and into the field in order to enhance student learning. During day trips, students examine Cambrian, Ordovician and modern sedimentary geology in the Ottawa region to observe, describe, and interpret depositional systems first hand. The suite of past and modern systems includes: glacial and river deposition; aeolian and coastal siliciclastic environments; siliciclastic estuarine conditions; and, peritidal through to outer platform carbonate environments. This course is an Ottawa-based equivalent of the field course ERTH 3203 that is held in Nova Scotia or western Newfoundland.



ERTH 4807 class examines the Anza beach dinosaur track locality near Agadir, Morocco.

ERTH 3203

Applied Sedimentology Field Course in Newfoundland

In late August-early September 2018, Professors George Dix and Geoff Pignotta led the ERTH 3203 class to western Newfoundland where students examined modern and ancient depositional environments. This allowed coverage of environmental conditions spanning deep-ocean through terrestrial examples.



Visiting PhD student Xin analyzing isotopes in the new Neptune mass spectrometry lab.

Graduate Student Research Notable Achievements

Ph.D. Student Freya George was an invited speaker in the session on “Microstructures as an interpretative tool in igneous and metamorphic petrology” at the European Geosciences Union General Assembly in Vienna in April, 2018. Her talk (George and Gaidies 2018) is entitled, “3D textural and geochemical porphyroblast analysis: unravelling the integrated history of nucleation, growth and deformation.”

Ph.D. Student Nawaf Nasser won the 2018 Herbert Spencer Jennings Award for best student research publication from the International Society for Testate Amoeba Research. The paper (Nasser et al. 2016) is entitled, “Lacustrine arcellinina (testate amoebae) as bioindicators of arsenic contamination. Microbial Ecology” published in Microbial Ecology.

Ph.D. Student Nkechi Oruche published her results (Oruche et al., 2018) on the “Lithostratigraphy of the upper Turinian – lower Chatfieldian (Upper Ordovician) foreland succession, and a U-Pb ID-TIMS date

for the Millbrig volcanic ash bed in the Ottawa Embayment,” in Canadian Journal of Earth Sciences. The age date she presents is the most precise age estimate of the epicontinental Millbrig ash deposit, and it and revised lithostratigraphy helps to establish a new interpretation of a tectonically dynamic period of deposition in the Ottawa Embayment during the Late Ordovician.

Dr. Chris Rogers published his Ph.D. results (Rogers et al. 2018) entitled, “1590 and 1550 Ma Mafic Dyke Swarms of Western Laurentia: Mantle Plume Magmatism Shared with Australia” in Lithos. Sm-Nd isotope geochemistry is used to define a new Mammoth-Western Channel Large Igneous Province (LIP) in western Laurentia and provides further evidence for the nearest neighbours with the Gawler LIP in South Australia.

Ph.D. Student Xin Tong is visiting the department from China University of Geosciences. Xin is working with Drs. Shuangquan Zhang and Brian Cousen and studying Cenozoic volcanic rocks from Southwestern China. He has dedicated his time at Carleton to isotope geochemistry, analyzing Sr, Nd and Pb isotopic ratios using our newly installed Neptune MC-ICP-MS.

New insights into the famous inverted Barrovian sequence in medium-grade metamorphic rocks of the Sikkim Himalaya. *Ph.D. student Freya George and Professor Fred Gaidies* utilize novel techniques of high-resolution micro-computed tomography scanning of rock specimens, and laser-ablation inductively coupled mass-spectrometry (LA-ICP-MS) raster mapping of representative garnets in their research. Results document unexpected and decoupled zoning patterns of trace elements compared to major elements in all analysed garnet crystals. The heavy rare earth elements in garnet document early rotation in overprinted early-grown cores, with subsequent rim-ward annular structures potentially documenting a change in the diffusivity

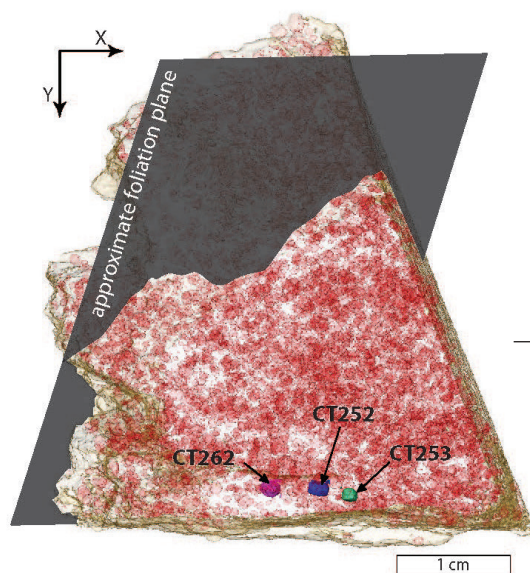
of these elements along the pressure-temperature path and fluctuating garnet growth rates. The chromium distribution in the same garnets exhibits continuous spiral patterns, a testament to its immobility at conditions $\leq 560^{\circ}\text{C}$ and the continued rotation of

garnet during growth. Trace elements in the study sample prove largely to be both spatially and temporally heterogeneous. The dataset

Featured Graduate Student Research

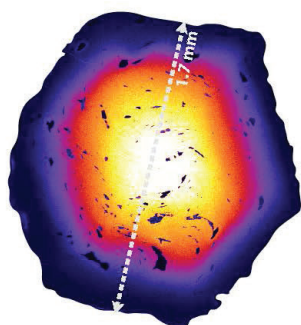
is the most comprehensive collected of its kind and highlights the importance of thorough investigation of population-wide garnet chemistry prior to interpretive approaches such as garnet geochronology and trace element geothermobarometry, so as to prevent spurious results.

George, F.R., Gaidies, F. & Boucher, B. 2018. Population-wide garnet growth zoning revealed by LA-ICP-MS mapping: implications for trace element equilibration and syn-kinematic deformation during crystallization, Contributions to Mineralogy and Petrology 173: 74.

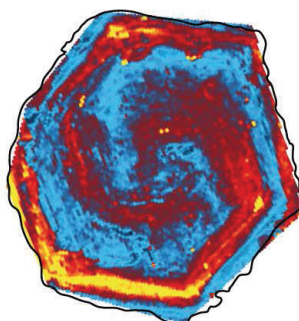


X-Y view of whole rock volume of sample 24-99 as scanned with X-ray μ -computed topography. The three largest garnets are highlighted (all other garnets in red), and the orientation of approximate foliation plane is illustrated.

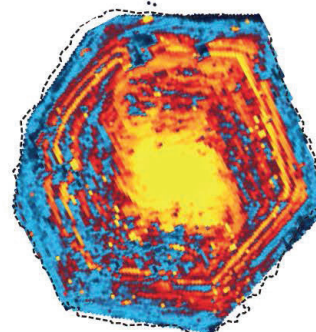
LA-ICP-MS raster maps of the largest garnet in 24-99 (CT252) showing the manganese, chromium and yttrium distributions. Warm and cool colours denote high and low concentrations, respectively.



Manganese



Chromium



Yttrium

FEATURED RESEARCH FROM OUR RECENTLY HIRED FACULTY

Professor Hanika Rizo is asking, "Did the early Earth have active plate tectonics?" Hanika and her colleague Bradford Foley from Pennsylvania State University are engaged in the debate about whether or not plate tectonics was in operation in the Hadean or early Archean Earth. Indirect constraints on early Earth tectonics can come from geochemical signatures in mantle rocks. These geochemical signatures suggest that portions of the mantle that were formed during Earth's "first moments" have survived their remixing into the mantle for more than a billion years. The survival of such signatures is difficult to explain because the early Earth's mantle was probably hot, with a low viscosity and vigorous convection. This often leads to the hypothesis that stagnant lid convection (i.e. no plate tectonics) was the prevalent style of tectonics in the early Earth. In a recent publication, Foley and Rizo (2017) suggest an alternative scenario, where plate tectonics could have been active in our planet when it was young.

B. J. Foley & H. Rizo, H. 2017. Long-term preservation of early formed mantle heterogeneity by mobile

lid convection: Importance of grainsize evolution. Earth and Planetary Science Letters, 475, 94-105.

Professor Jim Mungall studies origin of melts in IOA deposits. The origins of iron oxide-apatite (IOA) deposits like those mined at Kiruna, Sweden for centuries have been controversial for decades. Jim

and colleagues have recently published a paper in *Geology* showing that the El Laco volcano in Chile preserves glassy and devitrified materials in unconsolidated hematite-phosphate tephra. These materials are shown by experiment to form a pair of immiscible melts, one essentially composed of Fe_2O_3 , P_2O_5 , CO_2 , and H_2O , and the

other resembling a common potassic arc basalt, at moderate temperature and pressure. The paper argues that the existence of quenched immiscible melts in the tephra demonstrates conclusively that the El Laco and Kiruna-type Fe oxide ores must be magmatic in origin.

J.E. Mungall, K. Long, J.M. Brenan, D. Smythe & H.R. Naslund. 2018. Immiscible shoshonitic and Fe-P-oxide melts preserved in unconsolidated tephra at El Laco volcano, Chile, Geology. 46 (3): 255-258.



Volcanic bomb composed of hematite and Fe phosphate containing quenched silicate and Fe-P-O melts from El Laco.

Update on Professor Claudia Schröder-Adams Arctic and Paleoclimate studies.

Claudia's collaboration with the Goethe University of Frankfurt, Germany addressing 'Cretaceous High Arctic Paleoenvironmental and Paleoclimate Change' was awarded 290 000 Euro from the German Research Foundation. The funds primarily support

the research laboratory of her German colleague Prof. Jens Herrle and a postdoctoral position in Frankfurt. Funds also secure the team's next Arctic expedition to be led by Claudia in the summer of 2019 when they return to Axel Heiberg and Devon islands to continue field studies.



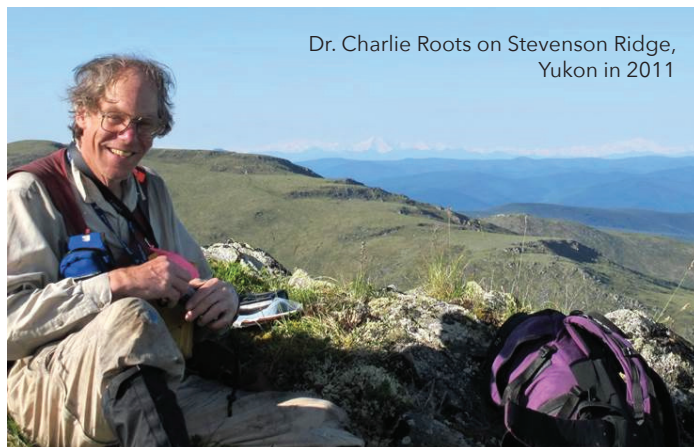
Claudia Schröder-Adams, Alex Quesnel and Jens Herrle performing field work at Glacier Fiord, Axel Heiberg Island.

Update on Large Igneous Provinces (LIP) research by Scientist-in-Residence Dr. Richard Ernst and his colleagues Professors Brian Cousens and Jim Mungall. Lecture tour. This fall, Richard shared his research results on Large Igneous Provinces and their importance for: paleocontinental reconstructions; ore, oil and gas exploration; and climate change research via 18 keynote-, guest- and short-course lectures in India (Banaras Hindu University, Varanasi India) and China (Beijing, Nanjing and Wuhan).

Congratulations. Richard and his colleagues were recently awarded a \$600,000 NSERC CRD grant entitled, "Developing the Full Potential of the Large Igneous Province (LIP) Record for Multi-Commodity, Multi-Scale Exploration Targeting".

FUND RAISING

SUPPORTING STUDENT RESEARCH



PLEASE SUPPORT THE CHARLIE ROOTS HONOURS PROJECT FUND IN EARTH SCIENCES – the university

will match gifts. Every year we have a cohort of 4th-year undergraduate Honours students carrying out exciting research projects on topics such as: Arctic research; fossils and implications for evolution or paleogeography; resource geology; crystal growth, metamorphism and mountain building; igneous rocks as geochemical tracers of Earth's history; early Earth and planetary geology; basin analysis; climate or sea level changes; natural vs. human contamination; hydrogeology; and many other earth sciences and environmental topics. Our target is to establish a large endowment so that the annual interest gener-

ated will help support the direct costs of field and/or laboratory work for student projects, year after year, in perpetuity. In naming this endowment, we wish to honour Dr. Charles Frederick Roots (1956-2016), a remarkable alumnus (MSc/82 PhD/88) who was an avid geologist, mentor, outdoorsman and all around scientist.

We are launching a new phase of our fundraising campaign on Giving Tuesday, November 27th, 2018.

For more information and to donate, please contact:

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Visit the Future Funder website at:
<https://futurefunder.carleton.ca/campaigns/charlie-roots-honours-project-fund-in-earth-sciences/>

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